

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-206952

(43)Date of publication of application : 13.08.1993

(51)Int.Cl.

H04B 10/18

(21)Application number : 04-237632

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(22)Date of filing : 14.08.1992

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(30)Priority

Priority number : 91 745539

Priority date : 15.08.1991

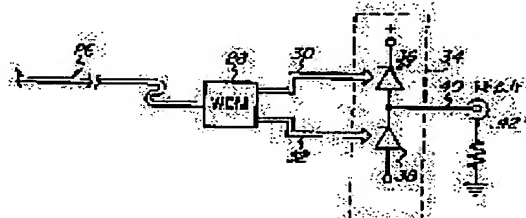
Priority country : US

(54) LOW-DISTORTION LASER SYSTEM FOR AMPLITUDE-MODULATION FIBER OPTICS COMMUNICATION

(57)Abstract:

PURPOSE: To eliminate a distortion component generated by the laser transmitter of an analog optical transmission system.

CONSTITUTION: A first optical carrier is modulated by using an information signal and a second optical carrier is modulated by inverting the information signal. The modulated first and second carriers are multiplexed into a single optical signal and the optical signal is transmitted through an optical-fiber transmission line. A receiver divides the optical signal into the carriers and restores the information signal and the inverted information signal. Then the receiver provides the information signal of an electrical area which is reduced in distortion by coupling both restored signals with each other. Therefore, a double detector balanced photodiode pair can be used for providing an analog RF output by coupling the restored information signal and inverted information signal. This device is practically suitable for the transmission of AM-VSB television signals.

**LEGAL STATUS**

[Date of request for examination] 05.11.1992

[Date of sending the examiner's decision of rejection] 12.12.1995

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision
of rejection]

[Date of requesting appeal against examiner's
decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] A means by which said communication device generates the 1st light subcarrier in the equipment which communicates an analog signal on an optic fiber communication way, A means to modulate said 1st light subcarrier with an analog information signal, and a means to reverse the phase of said analog information signal, The communication device characterized by consisting of a means to generate the 2nd light subcarrier, a means to modulate said 2nd light subcarrier with said reversal analog information signal, and a multiplexing means to multiplex to a lightwave signal independent in order to transmit said 1st and 2nd light subcarrier on an optical-fiber-transmission way.

[Claim 2] The communication device according to claim 1 characterized by consisting of the coupling means which said communication device combines the restored signal with a separation means to be further connected to the remote edge of said optic fiber communication way, to separate said lightwave signal, and to restore said information signal and a reversal information signal, and it provides with said information signal where a strain is mitigated in an electric field.

[Claim 3] The communication device according to claim 2 characterized by said coupling means consisting of a duplex wave detector balance light diode pair.

[Claim 4] The communication device according to claim 2 with which said coupling means inputs said restored information signal, and is characterized by consisting of the 1st photodetector which outputs the electrical signal corresponding to it, the 2nd photodetector which inputs said restored reversal information signal and outputs the electrical signal corresponding to it, and the transformer which inputs the electric generating power from said 1st and 2nd photodetectors, and is combined.

[Claim 5] A communication device given in claim 2 thru/or any of 4 they are. [which is characterized by for said multiplexing means consisting of a wavelength division multiplexer, and said separation means consisting of a wavelength division demultiplexer]

[Claim 6] A communication device given in claim 1 thru/or any of 5 they are. [which is characterized by keeping slight spacing between the wavelength of said 1st laser, and the wavelength of said 2nd laser in order for said 1st light subcarrier generation means to consist of the 1st laser, and for said 2nd light subcarrier generation means to consist of the 2nd laser and to make easy multiplexing and separation of the 1st and 2nd light subcarrier which were modulated]

[Claim 7] A communication device given in claim 1 thru/or any of 6 they are. [which is characterized by said 1st and 2nd light subcarrier generation means consisting of semiconductor laser]

[Claim 8] The communication device according to claim 1 characterized by said multiplexing means consisting of a wavelength division multiplexer.

[Claim 9] A communication device given in claim 1 thru/or any of 8 they are. [which is characterized by said information signal consisting of an analog amplitude-modulated signal]

[Claim 10] In the receiver which restores an analog information signal from the 2nd optical fiber which carries out 180-degree phase shift of the 1st optical fiber which transmits an information signal, and said information signal, and transmits them A means by which said receiver combines

said 1st optical fiber with the first detector of said optical receiver optically with a duplex wave detector balance light diode pair, When it consists of a means to combine said 2nd optical fiber with the 2nd wave detector of said optical receiver optically and said optical receiver combines the information signal from the 1st optical fiber, and the phase shift information signal from the 2nd optical fiber The receiver characterized by eliminating the strain component contained there, falling strain level and outputting said information signal in an electric field.

[Claim 11] The receiver according to claim 10 characterized by consisting of a means to receive the optical input signal with which said receiver includes said phase shift information signal and said multiplexed information signal further, and a separation means to separate the received optical input signal, to provide said 1st optical fiber with said information signal, and to provide said 2nd optical fiber with said phase shift information signal.

[Claim 12] The receiver according to claim 11 characterized by said separation means consisting of a light wave length division demultiplexer.

[Claim 13] In the receiver which restores an analog information signal from the optical input signal transmitted with the optical fiber Said receiver is connected to said fiber and said optical input signal is separated. A separation means to restore said information signal and the reversal signal of said information signal, The receiver characterized by consisting of the coupling means which combines with the reversal information signal which had the restored information signal restored, eliminates the strain component contained there, falls strain level and outputs said information signal in an electric field.

[Claim 14] The receiver according to claim 13 characterized by said separation means consisting of a wavelength division demultiplexer.

[Claim 15] The receiver according to claim 13 or 14 with which said coupling means inputs said restored information signal, and is characterized by consisting of the 1st photodetector which outputs the electrical signal corresponding to it, the 2nd photodetector which inputs said restored reversal information signal and outputs the electrical signal corresponding to it, and the transformer which inputs the electric generating power from said 1st and 2nd photodetectors, and is combined.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the equipment which eliminates the strain component produced with a laser transmitter in more detail about an analog lightwave transmission system.

[0002]

[Description of the Prior Art] The lightwave transmission system is realized by use in current and various communication link fields. For example, current use of the telephone system which uses the optical fiber technique for long-distance transmission of voice and a data signal is carried out. Similarly, the cable television network which used the optical fiber technique for transmission of both an analog signal and a digital signal is also working now.

[0003] Before the optical transmission network was realized, the cable television program was transmitted as a radio frequency (RF) signal with the electric coaxial cable. In a fiber-optic transmission system, a multi-channel TV signal is transmitted using communication link laser. The light source is modulated using a RF signal and the modulated light is transmitted along with the die length of an optical fiber.

[0004] A lightwave transmission system begins unrestricted bandwidth, improvement in system performance, etc. substantially, and has a remarkable advantage. However, harmonic distortion becomes big constraint of an analog amplitude modulation optical-communication transmitting system. Especially a secondary strain is introduced by such a strain and the laser which transmits a signal to an optical transmission system.

[0005] U.S. Pat. No. 4,393,518 "optical-communication equipment" published by 12 in July, 1983 is indicating the lightwave transmission system containing the transmitter which transmits an electric analog input signal to a receiver as two separated lightwave signals through one pair of optical fibers. One of the two of a lightwave signal expresses the forward part of an input signal. Another side expresses the negative part of an input signal. It is generated by combining two lightwave signals with a receiver, without the electric analog output signal showing an input signal containing the even harmonics component possibly produced during transmission. A receiver needs various amplifier including the differential amplifier, in order to reproduce an input signal.

[0006] The U.S. application 07th entitled "the fiber-optic transmission system which eliminates a strain" of the copending application transferred to the same grantee / No. 436,614 are indicating the structure of transmitting an analog input signal to a receiver with one fiber, and transmitting to a receiver what reversed the input signal with a separate juxtaposition fiber. A signal is combined with a receiver and the harmonic distortion produced during transmission of a signal is canceled. Since the whole input signal is transmitted through both juxtaposition fibers, even when fiber of one of the two is cut, although quality deteriorates, it can restore the transmitted information.

[0007]

[Problem(s) to be Solved by the Invention] As for above-mentioned strain elimination structure, a fault has both. For example, since it is necessary to use a juxtaposition fiber, the construction costs of a transmission network become high. Moreover, the design of a receiver becomes a

little complicated and implementation costs become comparatively expensive.

[0008] It is useful to offer the amelioration system which eases the strain of the optical fiber system which transmits analog signals, such as an amplitude modulation vestigial sideband (AM-VSB) TV signal. This invention offers such equipment.

[0009]

[Means for Solving the Problem] In this invention, the equipment for transmitting an analog signal on an optical-fiber-transmission way is offered. In order to generate the 1st light subcarrier, means, such as semiconductor laser, are equipped. The 1st light subcarrier is modulated with information signals, such as an analog AM signal. The phase of an information signal is reversed and a means to modulate the 2nd light subcarrier with the information signal after reversal is equipped. The 2nd light subcarrier as well as the 1st light subcarrier is generable with semiconductor laser. In order to transmit on one optic fiber communication way, the means which multiplexes both subcarriers to an independent lightwave signal (multiplexing) is equipped.

[0010] It connects with the remote edge of an optic fiber communication way, and a receiver includes a means to separate a multiplexing lightwave signal (demulti pre KUSHINGU), and to restore an information signal and a reversal information signal. The restored signal is combined and the information signal of the electric field which eased the strain is offered. In the suitable example, this coupling means consists of a duplex wave detector balance light diode pair. It consists of the 1st photodetector which outputs the electrical signal which receives the information signal with which the coupling means was restored in the another example, and corresponds, the 2nd photodetector which outputs the electrical signal which receives the restored reversal information signal and corresponds, and the transformer which receives the electric generating power from the 1st and 2nd photodetectors, and is combined.

[0011] A multiplexer means to use it with a transmitter can consist of wavelength division multiplexers. A demultiplexer means can consist of wavelength division multiplexers which operate to hard flow and function as a wavelength division demultiplexer. Multiplexing and separation of the 1st and 2nd light subcarrier which were modulated become easy by detaching the wavelength of a laser transmitter for a while mutually.

[0012]

[Example] Drawing 1 shows the transmitter by this invention. The conventional RF modulator 10 generates many AM-VSB television signals, and they are inputted into the RF-signal splitter 12. The signal splitter 12 offers two paths of a RF signal. In the 1st path, a signal is reversed by the inverter 14, and it outputs to a track 21, and is used for the modulation of optical subcarrier generators, such as semiconductor laser 22. Laser 22 outputs the optical subcarrier of the predetermined wavelength of 1.5 microns. By modulating a laser output by the RF signal from an inverter 14, a reversal input signal can be transmitted with an optical fiber. In this industry, either the direct modulation of an optical subcarrier generator or external modulation can be used like common knowledge.

[0013] After decreasing the amplitude of an input signal if needed with an attenuator 16, the amplitude of RF modulating-signal output of a track 19, an inclination, and a phase are made in agreement with the phase-inversion-modulation signal output of a track 21 in the 2nd RF path offered by the splitter 12 by adjusting in conventional RF inclination and the conventional phase adjustment circuit 18. The only difference of the signal of a track 19 and a track 21 is that 180 degrees of phases of the signal of a track 21 have shifted from the phase of the signal of a track 19.

[0014] The RF signal which the track 19 adjusted is combined with the modulation input of semiconductor laser 20 so that it can transmit by the optical subcarrier generated by laser 20. The wavelength (about 2 - 5 nanometers) of laser 20 is slightly shifted from the wavelength of laser 22, and the conventional wavelength-division-multiplex-izing / division technique are used for it, and it enables it to multiplex and divide each subcarrier output of laser 20 and 22 in the suitable example.

[0015] In the example shown in drawing 1, the subcarrier output which laser 20 and 22 modulated is inputted into the conventional wavelength division multiplexer (WDM) 24. WDM24 combines two modulation subcarriers and outputs them to an optical fiber 26 as an independent

lightwave signal. In order to maintain signal strength covering a long distance, along with a fiber 26, one or more optical amplifiers (not shown), such as erbium fiber amplifier, can be equipped. [0016] Drawing 2 shows one example of the receiver of the multiplexing lightwave signal transmitted with the optical fiber. The signal from an optical fiber is inputted into the wavelength division multiplexer 28 which operates to hard flow and offers a split. In this way, the modulation subcarrier which the modulation subcarrier outputted from laser 20 was restored with the optical fiber 30 including the information which was caused modulator 10 and offered, and was outputted from laser 22 including reversal information is restored by the optical fiber 32. In order to maintain the balance of the restored subcarrier, as for fibers 30 and 32, it is desirable to combine with one at spacing controlled strictly in agreement with spacing of the photodetector combined in order to receive a restoration subcarrier.

[0017] the example shown in drawing 2 -- the information signal from a fiber 30, and the reversal information signal from a fiber 32 -- a duplex wave detector balance light diode pair -- it inputs into the photodetectors 36 and 38 of 34, respectively. Diode pair 34 for example "high-speed monolithic GainAS dual pin photo diode for balanced light wave receivers" (it Makiuchi(s) M. --) of M. MAKIUCHI and others in the 1144 - 1145 pages of the electronics Letters volume [25th] No. 17 August 17, 1989 issues et al, "High-Speed Monolithic GainAs Twin-pinPhotodiode for Balanced Optical Coherent Receivers", and Electronics It can constitute from a high-speed monolithic component which was indicated by Letters, 17 August 1989, Vol.25, No.17, and pp.1144-1145 and which built two diodes into balanced mixer structure.

[0018] Since the inphase component exclusion capacity of the dark current of photo diode is high when it creates on the same substrate, the pair of the differential photo diodes 36 and 38 has the advantage that the noise power of an output is considerably mitigable. By carrying photo diode on a common substrate, the RF inphase component exclusion capacity of the frequency component produced when the separated photo diode is used for detection also becomes high. If the photo diode pair adjusted well is used, since only an independent electron device can restore RF information signal, high cost effectiveness is acquired in this example of application. Diode pair 34 combines the information and reversal information which obtained from the lightwave signal ways 30 and 32, respectively, and were transmitted, and where a strain is mitigated in an electric field, it restores RF input signal of the origin outputted from the modulator 10. The restored RF signal is outputted to the RF output terminals 42, such as the conventional coaxial connector, through the electrical signal way 40. the even harmonics introduced with the component, which are laser or others, during transmission of a signal by combining with the reversal information which modulated the modulated information -- a diode pair -- while being eliminated by 34, the output power of a desired information signal is doubled.

[0019] Drawing 3 shows another example of a receiver. Here, the restored modulation light subcarrier is changed into the electrical signal corresponding to it using the separated separate photo detectors 50 and 52. After amplifying noninverting information with the conventional RF amplifier 54, it is inputted into a primary a transformer 58 side. After amplifying reversal information with the RF amplifier 56, it is inputted into a primary a transformer 58 side. A transformer 58 combines a reversal information signal and a noninverting information signal by the conventional approach, and outputs a joint signal. At this time, even harmonics are eliminated, it doubles and the power of a desired information signal is outputted to the RF output terminal 60.

[0020] Elimination of the even harmonics strain by association of a reversal information signal and a noninverting information signal and doubling of output power can be expressed mathematically. For example, laser 20 (drawing 1 R> 1) can be modulated with RF input signal "EIN." The signal outputted to an optical fiber 30 by the wavelength division multiplexer 28 can be expressed as follows as EOUT1.

$EOUT1 = K0 + K1 \text{ EIN} + K2 \text{ 2 (EIN)} + K3 \text{ 3 (EIN)} + \dots$ It is K0 here. DC component of a signal and EIN are the information signal restored and K2 2 (EIN). The secondary harmonic strain component of an input signal, and K3 3 (EIN) It is the 3rd strain component and continues like the following.

[0021] 180 degrees of phases have shifted from EIN, and RF input signal inputted into laser 22 can be expressed as "-EIN." Therefore, the restoration signal EOUT2 outputted to an optical

fiber 32 can be expressed as follows.

$E_{OUT2} = -K_0 + K_1 + (-E_{IN}) K_2 + 2(-E_{IN}) + K_3 + 3(-E_{IN}) + \dots$ In E_{OUT2} , the oddth product all serves as negative and the eventh product all serves as forward so that it may understand now. Therefore, the magnitude of E_{OUT1} and E_{OUT2} is equal, since DBOR34 or a transformer 58 combines a signal and E_{OUT2} is effectively subtracted from E_{OUT1} when 180 degrees of phases have shifted, all the eventh components are eliminated and, as for all the oddth components (the signal E_{IN} which should be restored is included), strength is doubled. While the signal level of the RF signal restored increases 3dB by this, the secondary harmonic strain component acting as a failure is eliminated.

[0022] Drawing 4 shows another example of the communication system of this invention. The laser 20 and 22 of the transmitting section of this equipment is the same as that of drawing 1. However, the output of laser is not multiplexed by one. an output separate as a substituting method -- the respectively separate optical fibers 70 and 72 -- a diode pair -- it transmits to 34. a signal -- a diode pair -- an even harmonics strain is eliminated as mentioned above, restoring the information on desired by joining together by 34. The disadvantageous point of the example shown in drawing 4 is that a transmitter to a receiver must maintain a juxtaposition fiber transmission line all the time.

[0023] It must have been understood that it is what this invention provides with the equipment which transmits a signal by few strains at an optical fiber by the above explanation. If a duplex wave detector balance light diode pair is used, it becomes easy to restore an information signal, eliminating an eventh harmonic strain, and it is advantageous. Although this invention was explained in relation to some suitable examples, this contractor will have it understood without deviating from the pneuma and the range of this invention indicated to a claim that various adaptation and change can be added to this.

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TECHNICAL FIELD

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PRIOR ART

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As for above-mentioned strain elimination structure, a fault has both. For example, since it is necessary to use a juxtaposition fiber, the construction costs of a transmission network become high. Moreover, the design of a receiver becomes a little complicated and implementation costs become comparatively expensive.

[0008] It is useful to offer the amelioration system which eases the strain of the optical fiber system which transmits analog signals, such as an amplitude modulation vestigial sideband (AM-VSB) TV signal. This invention offers such equipment.

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MEANS

[Means for Solving the Problem] In this invention, the equipment for transmitting an analog signal on an optical-fiber-transmission way is offered. In order to generate the 1st light subcarrier, means, such as semiconductor laser, are equipped. The 1st light subcarrier is modulated with information signals, such as an analog AM signal. The phase of an information signal is reversed and a means to modulate the 2nd light subcarrier with the information signal after reversal is equipped. The 2nd light subcarrier as well as the 1st light subcarrier is generable with semiconductor laser. In order to transmit on one optic fiber communication way, the means which multiplexes both subcarriers to an independent lightwave signal (multiplexing) is equipped.

[0010] It connects with the remote edge of an optic fiber communication way, and a receiver includes a means to separate a multiplexing lightwave signal (demulti pre KUSHINGU), and to restore an information signal and a reversal information signal. The restored signal is combined and the information signal of the electric field which eased the strain is offered. In the suitable example, this coupling means consists of a duplex wave detector balance light diode pair. It consists of the 1st photodetector which outputs the electrical signal which receives the information signal with which the coupling means was restored in the another example, and corresponds, the 2nd photodetector which outputs the electrical signal which receives the restored reversal information signal and corresponds, and the transformer which receives the electric generating power from the 1st and 2nd photodetectors, and is combined.

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EXAMPLE

[Example] Drawing 1 shows the transmitter by this invention. The conventional RF modulator 10 generates many AM-VSB television signals, and they are inputted into the RF-signal splitter 12. The signal splitter 12 offers two paths of a RF signal. In the 1st path, a signal is reversed by the inverter 14, and it outputs to a track 21, and is used for the modulation of optical subcarrier generators, such as semiconductor laser 22. Laser 22 outputs the optical subcarrier of the predetermined wavelength of 1.5 microns. By modulating a laser output by the RF signal from an inverter 14, a reversal input signal can be transmitted with an optical fiber. In this industry, either the direct modulation of an optical subcarrier generator or external modulation can be used like common knowledge.

[0013] After decreasing the amplitude of an input signal if needed with an attenuator 16, the amplitude of RF modulating-signal output of a track 19, an inclination, and a phase are made in agreement with the phase-inversion-modulation signal output of a track 21 in the 2nd RF path offered by the splitter 12 by adjusting in conventional RF inclination and the conventional phase adjustment circuit 18. The only difference of the signal of a track 19 and a track 21 is that 180 degrees of phases of the signal of a track 21 have shifted from the phase of the signal of a track 19.

[0014] The RF signal which the track 19 adjusted is combined with the modulation input of semiconductor laser 20 so that it can transmit by the optical subcarrier generated by laser 20. The wavelength (about 2 - 5 nanometers) of laser 20 is slightly shifted from the wavelength of laser 22, and the conventional wavelength-division-multiplex-izing / division technique are used for it, and it enables it to multiplex and divide each subcarrier output of laser 20 and 22 in the suitable example.

[0015] In the example shown in drawing 1, the subcarrier output which laser 20 and 22 modulated is inputted into the conventional wavelength division multiplexer (WDM) 24. WDM24 combines two modulation subcarriers and outputs them to an optical fiber 26 as an independent lightwave signal. In order to maintain signal strength covering a long distance, along with a fiber 26, one or more optical amplifiers (not shown), such as erbium fiber amplifier, can be equipped.

[0016] Drawing 2 shows one example of the receiver of the multiplexing lightwave signal transmitted with the optical fiber. The signal from an optical fiber is inputted into the wavelength division multiplexer 28 which operates to hard flow and offers a split. In this way, the modulation subcarrier which the modulation subcarrier outputted from laser 20 was restored with the optical fiber 30 including the information which was caused modulator 10 and offered, and was outputted from laser 22 including reversal information is restored by the optical fiber 32. In order to maintain the balance of the restored subcarrier, as for fibers 30 and 32, it is desirable to combine with one at spacing controlled strictly in agreement with spacing of the photodetector combined in order to receive a restoration subcarrier.

[0017] the example shown in drawing 2 -- the information signal from a fiber 30, and the reversal information signal from a fiber 32 -- a duplex wave detector balance light diode pair -- it inputs into the photodetectors 36 and 38 of 34, respectively. Diode pair 34 for example "high-speed monolithic GainAS dual pin photo diode for balanced light wave receivers" (it Makiuchi(s) M. --) of M. MAKIUCHI and others in the 1144 - 1145 pages of the electronics Letters volume [25th]

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[0019] Drawing 3 shows another example of a receiver. Here, the restored modulation light subcarrier is changed into the electrical signal corresponding to it using the separated separate photo detectors 50 and 52. After amplifying noninverting information with the conventional RF amplifier 54, it is inputted into a primary a transformer 58 side. After amplifying reversal information with the RF amplifier 56, it is inputted into a primary a transformer 58 side. A transformer 58 combines a reversal information signal and a noninverting information signal by the conventional approach, and outputs a joint signal. At this time, even harmonics are eliminated, it doubles and the power of a desired information signal is outputted to the RF output terminal 60.

[0020] Elimination of the even harmonics strain by association of a reversal information signal and a noninverting information signal and doubling of output power can be expressed mathematically. For example, laser 20 (drawing 1 $R > 1$) can be modulated with RF input signal "EIN." The signal outputted to an optical fiber 30 by the wavelength division multiplexer 28 can be expressed as follows as EOUT1.

$EOUT1 = K0 + K1 \text{ EIN} + K2 \text{ 2 (EIN)} + K3 \text{ 3 (EIN)} + \dots$ It is K0 here. DC component of a signal and EIN are the information signal restored and K2 2 (EIN). The secondary harmonic strain component of an input signal, and K3 3 (EIN) It is the 3rd strain component and continues like the following.

[0021] 180 degrees of phases have shifted from EIN, and RF input signal inputted into laser 22 can be expressed as "-EIN." Therefore, the restoration signal EOUT2 outputted to an optical fiber 32 can be expressed as follows.

$EOUT2 = -K0 + K1 + (-EIN) K2 \text{ 2 (-EIN)} + K3 \text{ 3 (-EIN)} + \dots$ In EOUT2, the oddth product all serves as negative and the eventh product all serves as forward so that it may understand now. Therefore, the magnitude of EOUT1 and EOUT2 is equal, since DBOR34 or a transformer 58 combines a signal and EOUT2 is effectively subtracted from EOUT1 when 180 degrees of phases have shifted, all the eventh components are eliminated and, as for all the oddth components (the signal EIN which should be restored is included), strength is doubled. While the signal level of the RF signal restored increases 3dB by this, the secondary harmonic strain component acting as a failure is eliminated.

[0022] Drawing 4 shows another example of the communication system of this invention. The laser 20 and 22 of the transmitting section of this equipment is the same as that of drawing 1 . However, the output of laser is not multiplexed by one. an output separate as a substituting method -- the respectively separate optical fibers 70 and 72 -- a diode pair -- it transmits to 34. a signal -- a diode pair -- an even harmonics strain is eliminated as mentioned above, restoring the information on desired by joining together by 34. The disadvantageous point of the example shown in drawing 4 is that a transmitter to a receiver must maintain a juxtaposition fiber

transmission line all the time.

[0023] It must have been understood that it is what this invention provides with the equipment which transmits a signal by few strains at an optical fiber by the above explanation. If a duplex wave detector balance light diode pair is used, it becomes easy to restore an information signal, eliminating an eventh harmonic strain, and it is advantageous. Although this invention was explained in relation to some suitable examples, this contractor will have it understood without deviating from the pneuma and the range of this invention indicated to a claim that various adaptation and change can be added to this.

[Translation done.]

* NOTICES *

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3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Drawing 1 is the block diagram of the transmitter by this invention, is single track about an electrical signal way, and shows a lightwave signal way by the double line.

[Drawing 2] Drawing 2 is the block diagram showing one example of the receiver by this invention, and expresses a lightwave signal way with the double line.

[Drawing 3] Drawing 3 is the block diagram showing another example of the receiver by this invention, and expresses a lightwave signal way with the double line.

[Drawing 4] It is the block diagram which transmits signal transmission to a duplex wave detector balance light diode pair by two juxtaposition lightwave signal ways expressed with the double line and in which showing another example of this invention.

[Translation done.]

* NOTICES *

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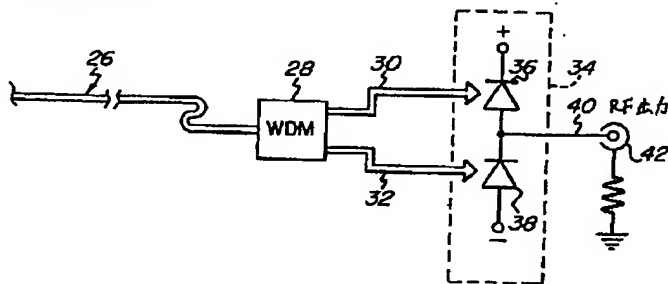
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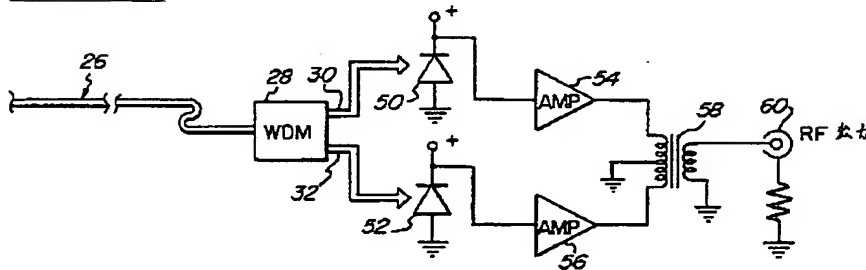
3.In the drawings, any words are not translated.

DRAWINGS

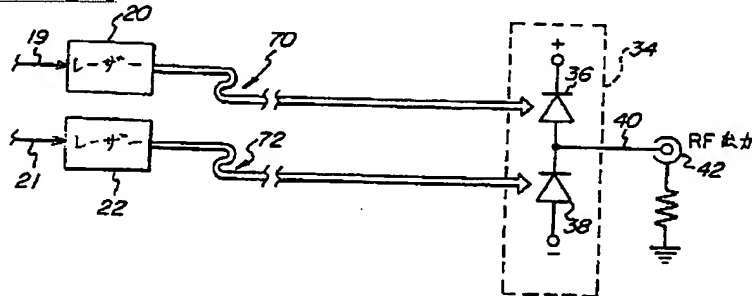
[Drawing 2]



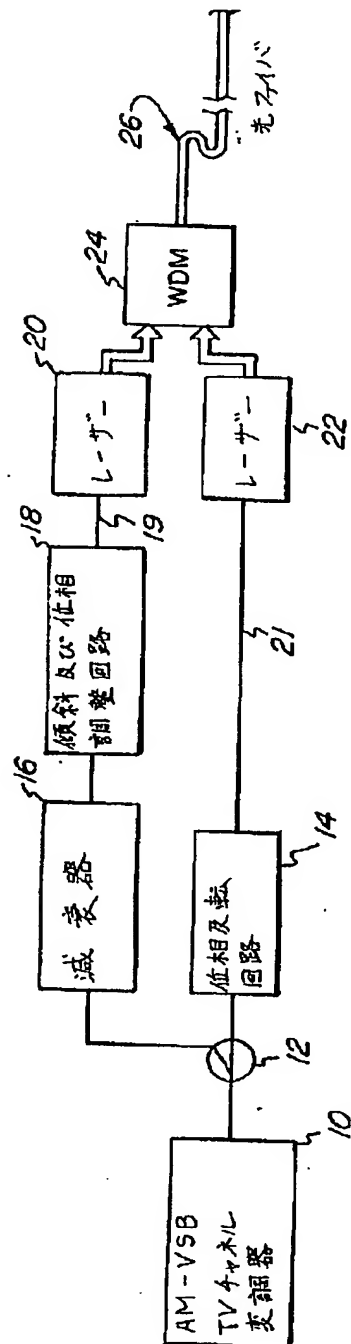
[Drawing 3]



[Drawing 4]



[Drawing 1]



[Translation done.]

(19)日本国特許庁(JP)

(12) 公開特許公報(A)

(11)特許出願公開番号

特開平5-206952

(43)公開日 平成5年(1993)8月13日

(51)Int.Cl. ⁵	識別記号	庁内整理番号	FI	技術表示箇所
H 0 4 B 10/18		8426-5K	H 0 4 B 9/ 00	M

審査請求 有 請求項の数15(全 6 頁)

(21)出願番号 特願平4-237632

(22)出願日 平成4年(1992)8月14日

(31)優先権主張番号 7 4 5 5 3 9

(32)優先日 1991年8月15日

(33)優先権主張国 米国(US)

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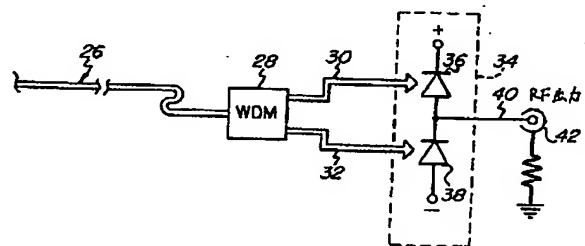
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(54)【発明の名称】 振幅変調光ファイバ通信用低ひずみレーザシステム

(57)【要約】

【目的】 本発明の装置は、アナログ光伝送システムに関し、レーザー送信機によって生じるひずみ成分を消去するためのものである。

【構成】 情報信号で第1光搬送波を変調する。情報信号を反転し、第2光搬送波を変調する。変調した第1および第2光搬送波を多重化して単独の光信号とし、光ファイバ伝送路で伝送する。受信機では、光信号を分離して、情報信号と反転情報信号を復元する。復元した両方の信号を結合し、ひずみを軽減した電気領域の情報信号を提供する。復元した情報信号と反転情報信号を結合して、アナログRF出力を提供するのに、二重検波器平衡光ダイオード対を使用することができる。本装置は特に、AM-VSBテレビジョン信号の伝送に適している。



【特許請求の範囲】

【請求項1】 アナログ信号を光ファイバ通信路で通信する装置において、前記通信装置が、
第1光搬送波を生成する手段と、
前記第1光搬送波をアナログ情報信号で変調する手段と、

前記アナログ情報信号の位相を反転する手段と、
第2光搬送波を生成する手段と、
前記第2光搬送波を前記反転アナログ情報信号で変調する手段と、
前記第1および第2光搬送波を光ファイバ伝送路で伝送するために単独の光信号に多重化する多重化手段とから成ることを特徴とする通信装置。

【請求項2】 前記通信装置がさらに、
前記光ファイバ通信路の遠隔端部に接続され、前記光信号を分離して、前記情報信号および反転情報信号を復元する分離手段と、
復元された信号を結合して、前記情報信号を電気領域でひずみを軽減した状態で提供する結合手段とから成ることを特徴とする、請求項1記載の通信装置。

【請求項3】 前記結合手段が二重検波器平衡光ダイオード対から成ることを特徴とする、請求項2記載の通信装置。

【請求項4】 前記結合手段が、
前記復元された情報信号を入力し、それに対応する電気信号を出力する第1光検波器と、
前記復元された反転情報信号を入力し、それに対応する電気信号を出力する第2光検波器と、
前記第1および第2光検波器からの電気出力を入力し結合する変成器とから成ることを特徴とする、請求項2記載の通信装置。

【請求項5】 前記多重化手段が波長分割マルチプレクサから成り、前記分離手段が波長分割デマルチプレクサから成ることを特徴とする、請求項2ないし4のいずれかに記載の通信装置。

【請求項6】 前記第1光搬送波生成手段が第1レーザから成り、
前記第2光搬送波生成手段が第2レーザから成り、
変調した第1および第2光搬送波の多重化および分離を容易にするために、前記第1レーザの波長と前記第2レーザの波長との間にわずかな間隔を置くことを特徴とする、請求項1ないし5のいずれかに記載の通信装置。

【請求項7】 前記第1および第2光搬送波生成手段が半導体レーザから成ることを特徴とする、請求項1ないし6のいずれかに記載の通信装置。

【請求項8】 前記多重化手段が波長分割マルチプレクサから成ることを特徴とする、請求項1記載の通信装置。

【請求項9】 前記情報信号がアナログ振幅変調信号から成ることを特徴とする、請求項1ないし8のいずれ

かに記載の通信装置。

【請求項10】 情報信号を伝送する第1光ファイバおよび前記情報信号を180°移相して伝送する第2光ファイバからアナログ情報信号を復元する受信機において、前記受信機が、
二重検波器平衡光ダイオード対と、
前記第1光ファイバを前記光受信機の第1検波器に光学的に結合する手段と、
前記第2光ファイバを前記光受信機の第2検波器に光学的に結合する手段とから成り、
前記光受信機が、第1光ファイバからの情報信号と第2光ファイバからの移相情報信号を結合することによって、そこに含まれるひずみ成分を消去し、前記情報信号を電気領域でひずみレベルを低下して出力することを特徴とする受信機。

【請求項11】 前記受信機がさらに、
前記移相情報信号と多重化した前記情報信号を含む光入力信号を受信する手段と、
受信した光入力信号を分離して、前記情報信号を前記第1光ファイバに提供し、前記移相情報信号を前記第2光ファイバに提供する分離手段とから成ることを特徴とする、請求項10記載の受信機。

【請求項12】 前記分離手段が光波長分割デマルチプレクサから成ることを特徴とする、請求項11記載の受信機。

【請求項13】 光ファイバで伝送された光入力信号からアナログ情報信号を復元する受信機において、前記受信機が、
前記ファイバに接続され、前記光入力信号を分離して、前記情報信号および前記情報信号の反転信号を復元する分離手段と、
復元された情報信号を復元された反転情報信号と結合して、そこに含まれるひずみ成分を消去し、前記情報信号を電気領域でひずみレベルを低下して出力する結合手段とから成ることを特徴とする受信機。

【請求項14】 前記分離手段が波長分割デマルチプレクサから成ることを特徴とする、請求項13記載の受信機。

【請求項15】 前記結合手段が、
前記復元された情報信号を入力し、それに対応する電気信号を出力する第1光検波器と、
前記復元された反転情報信号を入力し、それに対応する電気信号を出力する第2光検波器と、
前記第1および第2光検波器からの電気出力を入力し結合する変成器とから成ることを特徴とする、請求項13または14記載の受信機。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明はアナログ光伝送システムに関し、さらに詳しくは、レーザ送信機によって生じる

ひずみ成分を消去する装置に関する。

【0002】

【従来の技術】光伝送システムは現在、様々な通信分野での利用に実現されている。例えば、音声およびデータ信号の長距離伝送に光ファイバ技術を利用している電話システムが、現在使用されている。同様に、アナログ信号およびデジタル信号の両方の伝送に光ファイバ技術を利用したケーブルテレビ網も、現在稼働している。

【0003】光伝送網が実現される前は、ケーブルテレビ番組は電気同軸ケーブルで無線周波数(RF)信号として伝送された。光ファイバ伝送システムでは、通信レーザを利用してマルチチャネルテレビ信号を送信する。RF信号を用いて光源を変調し、変調された光を光ファイバの長さに沿って伝送する。

【0004】光伝送システムは、実質的に無制限の帯域幅やシステム性能の向上などをはじめ、かなりの利点がある。しかし、高調波ひずみは、アナログ振幅変調光通信送信システムの大きな制約になる。このようなひずみ、特に二次ひずみは、信号を光通信システムに送信するレーザによって導入される。

【0005】1983年7月12に発行された米国特許第4,393,518号「光通信装置」は、電気的アナログ入力信号を1対の光ファイバを介して2つの分離した光信号として受信機に伝送する送信機を含む光伝送システムを開示している。光信号の片方は、入力信号の正の部分を表わす。もう一方は、入力信号の負の部分を表わす。2つの光信号を受信機で結合することによって、入力信号を表わす電気的アナログ出力信号が、伝送中に生じたかもしれない偶数調波成分を含むことなく生成される。受信機は、入力信号を再生するために、差動増幅器をはじめとする様々な増幅器を必要とする。

【0006】同一譲受人に譲渡された同時係属出願の「ひずみを消去する光ファイバ伝送システム」と題する米国出願第07/436,614号は、アナログ入力信号を1本のファイバで受信機に伝送し、入力信号を反転したものを別個の並列ファイバで受信機に伝送する構造を開示している。受信機で信号を結合して、信号の伝送中に生じた高調波ひずみを解消する。入力信号全体が並列ファイバの両方を通して伝送されるので、片方のファイバが切断された場合でも、品質は低下するが、送信された情報を復元することができる。

【0007】

【発明が解決しようとする課題】上述のひずみ消去構造は両方とも欠点がある。例えば、並列ファイバを使用する必要があるため、伝送網の建設費用が高くなる。また、受信機の設計は幾分複雑になり、実現費用が比較的高価になる。

【0008】振幅変調残留側波帯(AM-VSB)テレビ信号などのようなアナログ信号を伝送する光ファイバシステムのひずみを緩和する改良システムを提供するこ

とは有益である。本発明はそうした装置を提供する。

【0009】

【課題を解決するための手段】本発明では、アナログ信号を光ファイバ伝送路で伝送するための装置を提供する。第1光搬送波を生成するために半導体レーザなどの手段を装備する。第1光搬送波を、アナログAM信号などの情報信号で変調する。情報信号の位相を反転し、反転後の情報信号で第2光搬送波を変調する手段を装備する。第1光搬送波と同様に、第2光搬送波も半導体レーザによって生成することができる。1つの光ファイバ通信路で伝送するために、両方の搬送波を単独の光信号に多重化(マルチプレクシング)する手段を装備する。

【0010】受信機は、光ファイバ通信路の遠隔端部に接続されて、多重化光信号を分離(デマルチプレクシング)して情報信号および反転情報信号を復元する手段を含む。復元された信号を結合して、ひずみを緩和した電気領域の情報信号を提供する。好適実施例では、この結合手段は二重検波器平衡光ダイオード対から成る。別の実施例では、結合手段は、復元された情報信号を受信して対応する電気信号を出力する第1光検波器と、復元された反転情報信号を受信して対応する電気信号を出力する第2光検波器と、第1および第2光検波器からの電気出力を受信し結合する変成器とから成る。

【0011】送信機で使用するマルチプレクサ手段は、波長分割マルチプレクサから構成することができる。デマルチプレクサ手段は、逆方向に作動して波長分割デマルチプレクサとして機能する波長分割マルチプレクサから構成することができる。変調した第1および第2光搬送波の多重化および分離は、レーザ送信機の波長を相互に少し離すことによって容易になる。

【0012】

【実施例】図1は、本発明による送信機を示す。多数のAM-VSBテレビジョン信号を従来のRF変調器10によって生成し、RF信号スプリッタ12へ入力する。信号スプリッタ12はRF信号の2つの経路を提供する。第1経路では、信号を位相反転回路14によって反転し、線路21へ出力して、半導体レーザ22などの光搬送波発生器の変調に使用する。レーザ22は、例えば1.5ミクロンといった所定の波長の光搬送波を出力する。位相反転回路14からのRF信号でレーザ出力を変調することによって、反転入力信号を光ファイバで伝送することができる。当業界では周知のごとく、光搬送波発生器の直接変調または外部変調のどちらでも使用することができる。

【0013】スプリッタ12によって提供される第2RF経路では、入力信号の振幅を減衰器16で必要に応じて減衰した後、従来のRF傾斜および位相調整回路18で調整することによって、線路19のRF変調信号出力の振幅、傾斜、および位相を線路21の位相反転変調信号出力と一致させる。線路19と線路21の信号の唯一

の相違は、線路21の信号の位相が、線路19の信号の位相と 180° ずれていることである。

【0014】線路19の調整したRF信号は、レーザ20によって発生される光搬送波で伝送することができるように、半導体レーザ20の変調入力に結合する。好適実施例では、レーザ20の波長は、レーザ22の波長からわずかに(例えば約2-5ナノメートルだけ)ずらし、従来の波長分割多重化/分割技術を用いてレーザ20、22のそれぞれの搬送波出力を多重化および分割することができるようにする。

【0015】図1に示す実施例では、レーザ20、22の変調した搬送波出力を、従来の波長分割マルチプレクサ(WDM)24に投入する。WDM24は2つの変調搬送波を結合し、単独の光信号として光ファイバ26に出力する。信号強度を長距離にわたって維持するために、ファイバ26に沿ってエルビウムファイバ増幅器などの光増幅器(図示せず)を1つ以上装備することができる。

【0016】図2は、光ファイバで伝送された多重化光信号の受信機の1つの実施例を示す。光ファイバからの信号は、逆方向に作動して分割機能を提供する波長分割マルチプレクサ28へ投入する。こうして、変調器10によって提供された情報を含み、レーザ20から出力した変調搬送波は、光ファイバ30で復元され、また反転情報を含み、レーザ22から出力した変調搬送波は、光ファイバ32で復元される。復元された搬送波の平衡を維持するために、ファイバ30と32は、復元搬送波を受信するために結合する光検波器の間隔と一致するように厳密に制御された間隔でひとつに結合することが望ましい。

【0017】図2に示す実施例では、ファイバ30からの情報信号およびファイバ32からの反転情報信号を、二重検波器平衡光ダイオード対34の光検波器36、38にそれぞれ投入する。ダイオード対34は、例えば、エレクトロニクス・レターズ第25巻17号1989年8月17日号1144-1145頁におけるM. マキウチらの「平衡光波受信機用の高速モノリシックGain Asデュアルピンホトダイオード」(M. Makiuchi, et al, "High-Speed Monolithic Gain As Twin-pin Photodiode for Balanced Optical Coherent Receivers", Elect

$$E_{out1} = K_0 + K_1 E_{in} + K_2 (E_{in})^2 + K_3 (E_{in})^3 + \dots$$

ここで K_0 は信号のDC成分、 E_{in} は復元される情報信号、 $K_2 (E_{in})^2$ は受信信号の二次調波ひずみ成分、 $K_3 (E_{in})^3$ は3次ひずみ成分であり、以下同様に続く。

$$E_{out2} = -K_0 + K_1 (-E_{in}) + K_2 (-E_{in})^2 + K_3 (-E_{in})^3 + \dots$$

これで分かるように、 E_{out2} では奇数次の積は全部負となり、偶数次の積は全部正となる。したがって、 E_{out1} と E_{out2} の大きさが等しく、位相が 180° ずれている

* ronics Letters, 17 August 1989, Vol. 25, No. 17, pp. 1144-1145)で開示された、平衡ミキサ構造に2つのダイオードを組み込んだ高速モノリシック素子から構成することができる。

【0018】差動ホトダイオード36、38の対は同一基板上に作成すると、ホトダイオードの暗電流の同相分排除能力が高いため、出力の雑音電力をかなり軽減することができるという利点がある。ホトダイオードを共通基板上に搭載することにより、分離したホトダイオードを検波に使用した場合に生じる周波数成分の高周波同相分排除能力も高くなる。よく整合したホトダイオード対を使用すれば、単独の電子デバイスだけでRF情報信号を復元することができるので、この適用例では高い費用効果が得られる。ダイオード対34は、光信号路30、32からそれぞれえ伝送された情報および反転情報を結合し、変調器10から出力された元のRF入力信号を電気領域でひずみを軽減した状態で復元する。復元されたRF信号は、電気信号路40を介して、従来の同軸コネクタなどのRF出力端子42へ出力される。変調した情報を変調した反転情報と結合することによって、信号の送信中にレーザまたはその他のコンポーネントによって導入された偶数調波がダイオード対34で消去される一方、所望の情報信号の出力電力は倍加される。

【0019】図3は、受信機の別の実施例を示す。ここでは、分離した別個の受光素子50、52を用いて、復元された変調搬送波をそれに対応する電気信号に変換する。非反転情報は、従来のRF増幅器54で増幅した後、変成器58の1次側へ投入する。反転情報は、RF増幅器56で増幅した後、変成器58の1次側へ投入する。変成器58は、反転情報信号と非反転情報信号を従来の方法で結合し、結合信号を出力する。このとき、偶数調波は消去され、所望の情報信号の電力は倍加されてRF出力端子60へ出力される。

【0020】反転情報信号と非反転情報信号の結合による偶数調波ひずみの消去および出力電力の倍加は、数学的に表現することができる。例えば、レーザ20(図1)はRF入力信号" E_{in} "で変調することができる。波長分割マルチプレクサ28によって光ファイバ30に出力される信号は、 E_{out1} として、次のように表わすことができる。

※【0021】レーザ22に投入されるRF入力信号は位相が E_{in} と 180° ずれており、" $-E_{in}$ "と表わすことができる。したがって、光ファイバ32に出力される復元信号 E_{out2} は、次のように表わすことができる。

場合、DBOR34または変成器58は信号を結合し、 E_{out1} から E_{out2} を効果的に引き算するので、全ての偶数次の成分は消去され、全ての奇数次の成分(復元すべ

き信号 E_{1n} を含む)は強さが倍加される。これにより、復元されるRF信号の信号レベルが3dB増加する一方、障害となる2次調波ひずみ成分は消去される。

【0022】図4は、本発明の通信システムの別の実施例を示す。この装置の送信部は、レーザ20、22までは図1と同一である。しかしレーザの出力はひとつに多重化されない。代替法として、別個の出力をそれぞれ別個の光ファイバ70、72でダイオード対34へ伝送する。信号をダイオード対34によって結合することによって、10 所望の情報を復元しながら、上述のように偶数調波ひずみを消去する。図4に示した実施例の不利な点は、送信機から受信機までずっと並列ファイバ伝送路を維持しなければならないことである。

【0023】以上の説明により、本発明が光ファイバで少ないひずみで信号を伝送する装置を提供するものであることが、理解されたはずである。二重検波器平衡光ダイオ

*イオード対を使用すると、偶数次調波ひずみを消去しながら情報信号を復元することが容易になり、有利である。本発明を幾つかの好適実施例に関連して説明したが、当業者は、請求の範囲に記載する本発明の精神および範囲から逸脱することなく、これに様々な適応や変化を加えることができることを理解されるだろう。

【図面の簡単な説明】

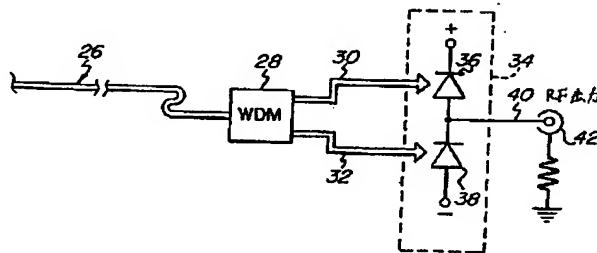
【図1】 図1は本発明による送信機のブロック図であり、電気信号路を単線で、光信号路を二重線で示す。

【図2】 図2は本発明による受信機の1実施例を示すブロック図であり、光信号路を二重線で表わす。

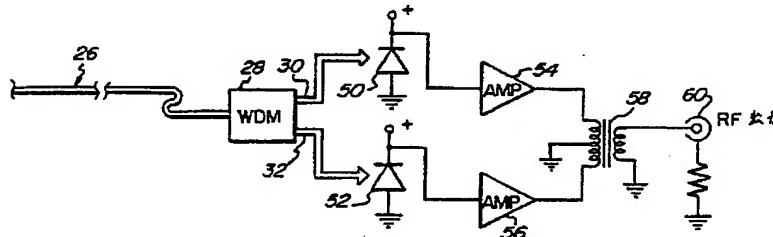
【図3】 図3は本発明による受信機の別の実施例を示すブロック図であり、光信号路を二重線で表わす。

【図4】 通信信号を二重線で表わす2つの並列光信号路により二重検波器平衡光ダイオード対に伝送する、本発明の別の実施例を示すブロック図である。

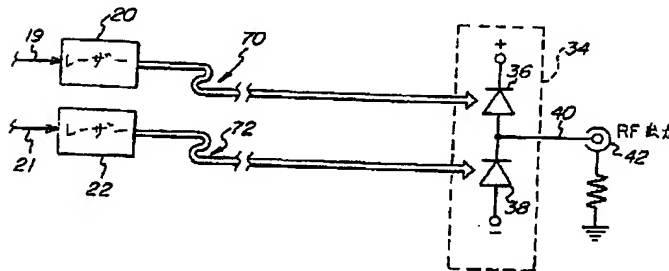
【図2】



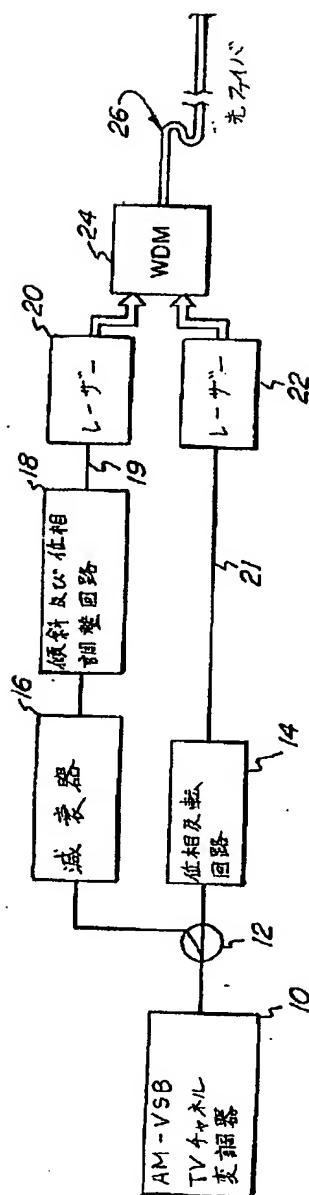
【図3】



【図4】



【図1】



フロントページの続き

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